310-344 AU 212 47902

GB 2002955
FEB 1979

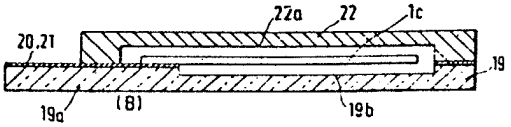
MATS- ★ R54 B8985B/09 ★GB 2002-955

Piezoelectric crystal oscillator for electronic watch - has planar support forming part of hermetically sealed housing

MATSUSHIMA KOGYO KK 19.07.77-JA-086277

(28.02.79) H03h-09/10

The quartz crystal oscillator assembly for an electronic watch has a hermetically sealed housing formed of separate parts(19, 22). At least one part is made of a piezoelectric crystalline material. The piezoelectric crystal oscillator element (1c) is supported in the housing by being mounted on a planar portion(19a) of one part.



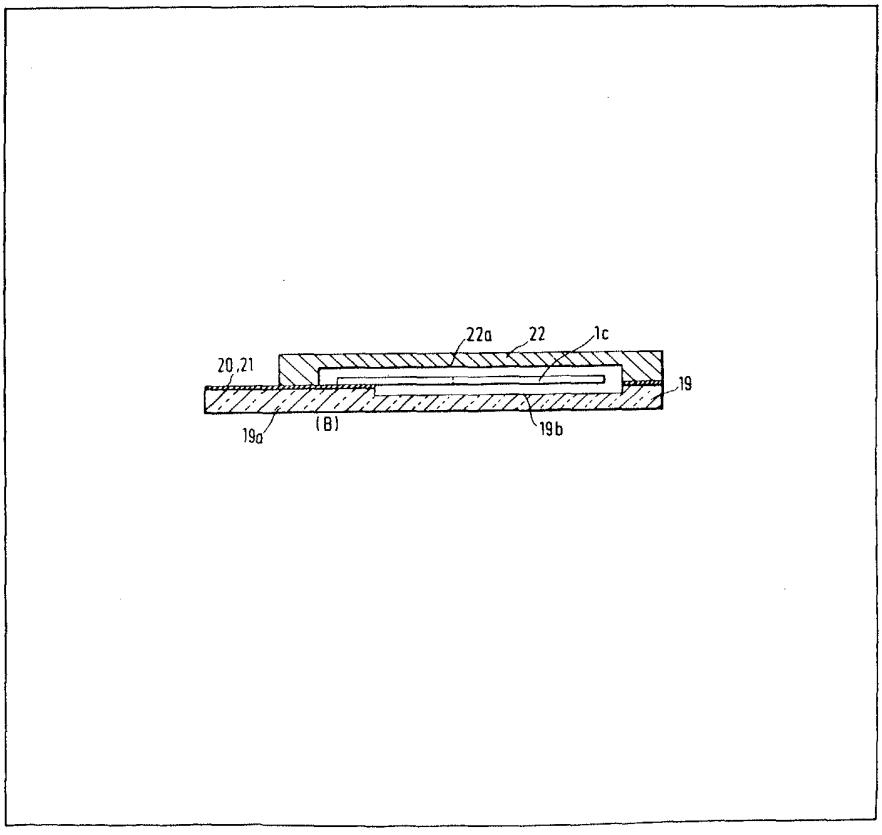
The housing material may be quartz and the one part of the housing may define a recess in which the oscillator element vibrates. The element may be mounted on spaced conductive films(20, 21) deposited on the planar support portion. 17.7.78 as 030132 (12pp1198)

(12) UK Patent Application (19) GB (11) 2 002 955 A

(21) Application No. **7830132**
(22) Date of filing **17 Jul 1978**
(23) Claims filed **17 Jul 1978**
(30) Priority data
(31) **52/086277**
(32) **19 Jul 1977**
(33) **Japan (JP)**
(43) Application published
28 Feb 1979
(51) **INT CL²**
H03H 9/10
(52) Domestic classification
H1E 1
(56) Documents cited
GB 1452570
GB 1448651
GB 1444504
GB 1381996
GB 1187441
(58) Field of search
H1E
(71) Applicant
Matsushima Kogyo Kabushiki Kaisha
3-3-5, Owa, Suwa-shi, Nagano-Ken, Japan
(72) Inventors
Mutsumi Negita
Joji Shimakawa
(74) Agents
J Miller & Co

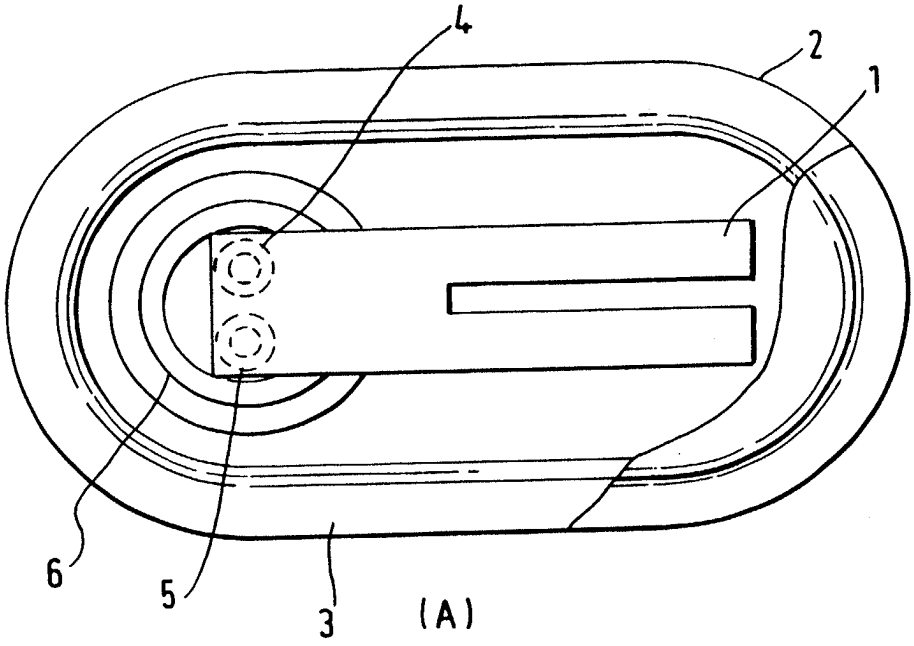
(54) **Piezo-electric oscillator assembly**

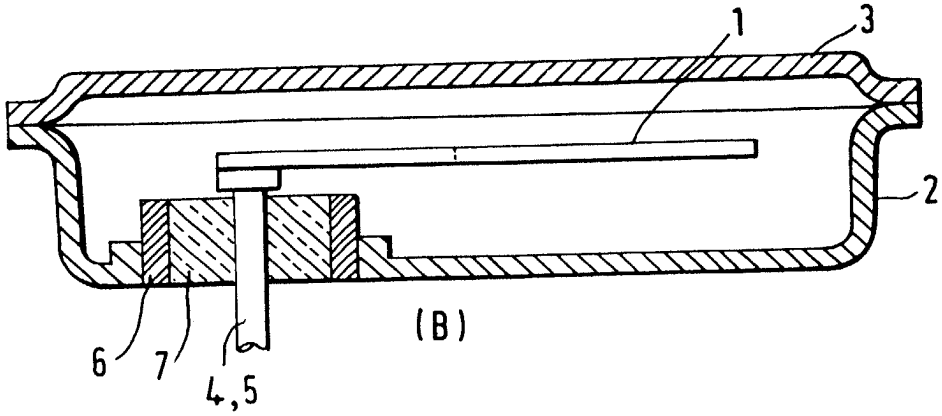
(57) An oscillator assembly comprises an hermatically sealed housing having a plurality of parts 19, 22 of which at least the part 19 is made of quartz crystal or other piezo-electric crystalline material. Disposed within the housing is an oscillator 1*c* of quartz crystal material which is mounted on a planar support portion 19*a* of the housing part 19. This provides the oscillator 1*c* with a more secure support than in the prior art, and prevents distortion arising from different thermal coefficients of expansion. Oscillators and upper and lower housing parts may be formed in strips by etching, and assembled together before separation. The housing part 22 may also be of quartz or of metal or glass. The recessed housing part 19 may be formed in two pieces, a frame on a plate. Conductive film connections 20, 21 pass through the housing.



2002955

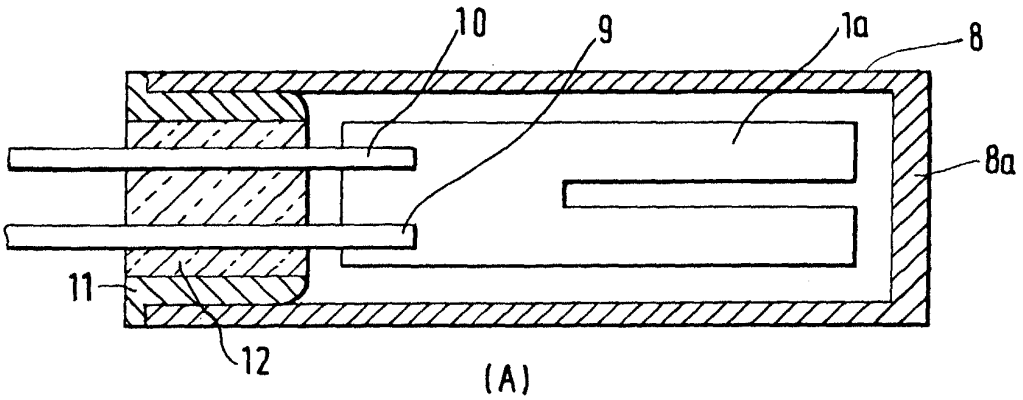
Fig. 1.



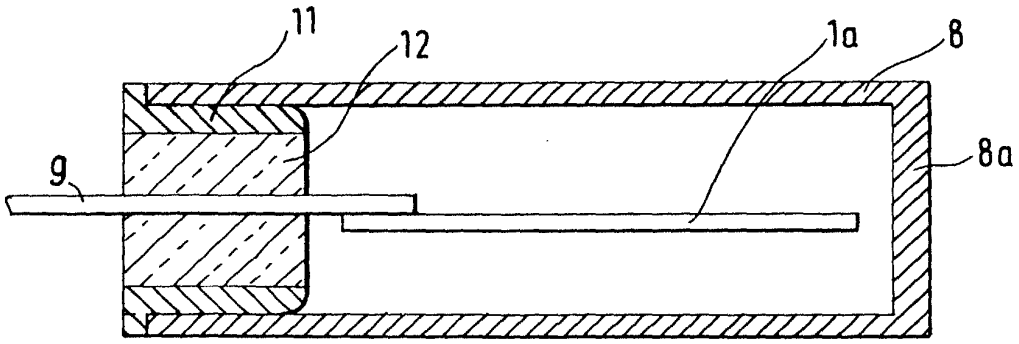


2002955

Fig. 2.



(A)



(B)

2002955

Fig.3.

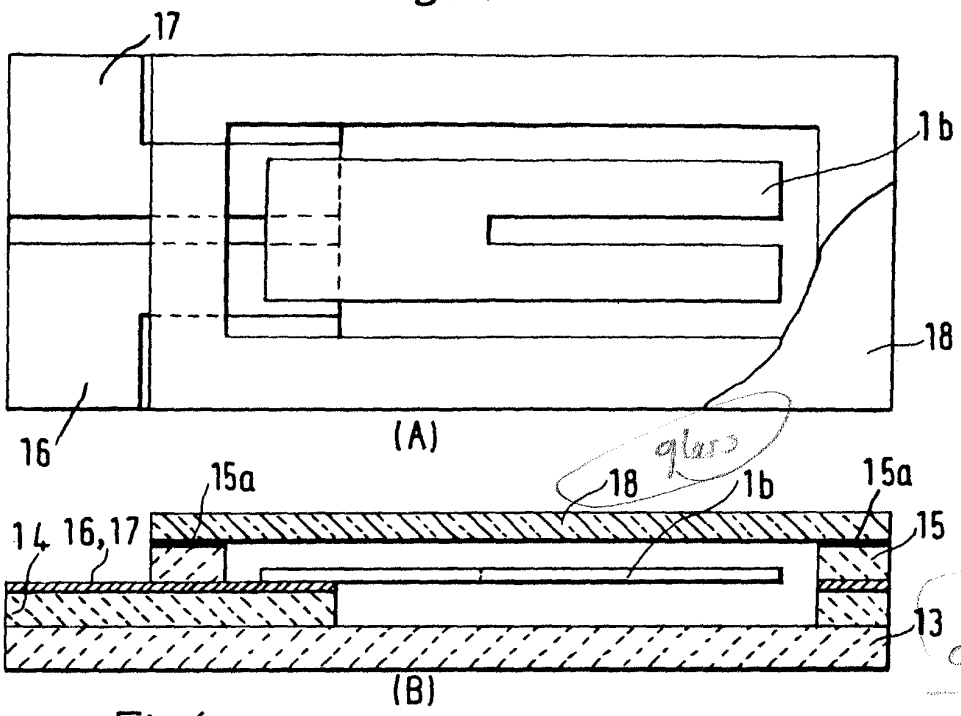


Fig.4.

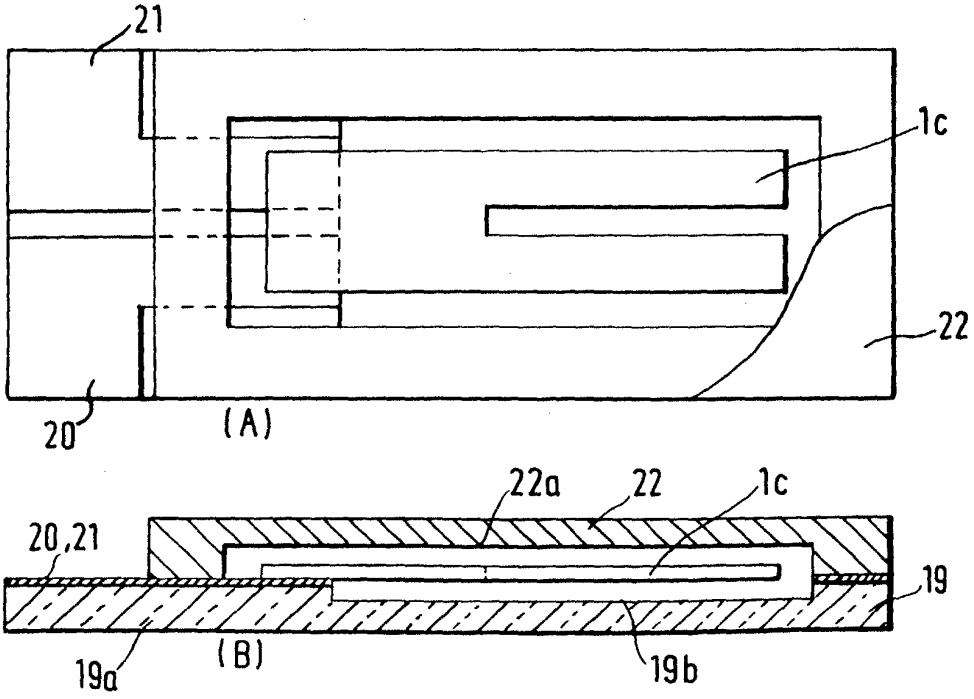


Fig.5.

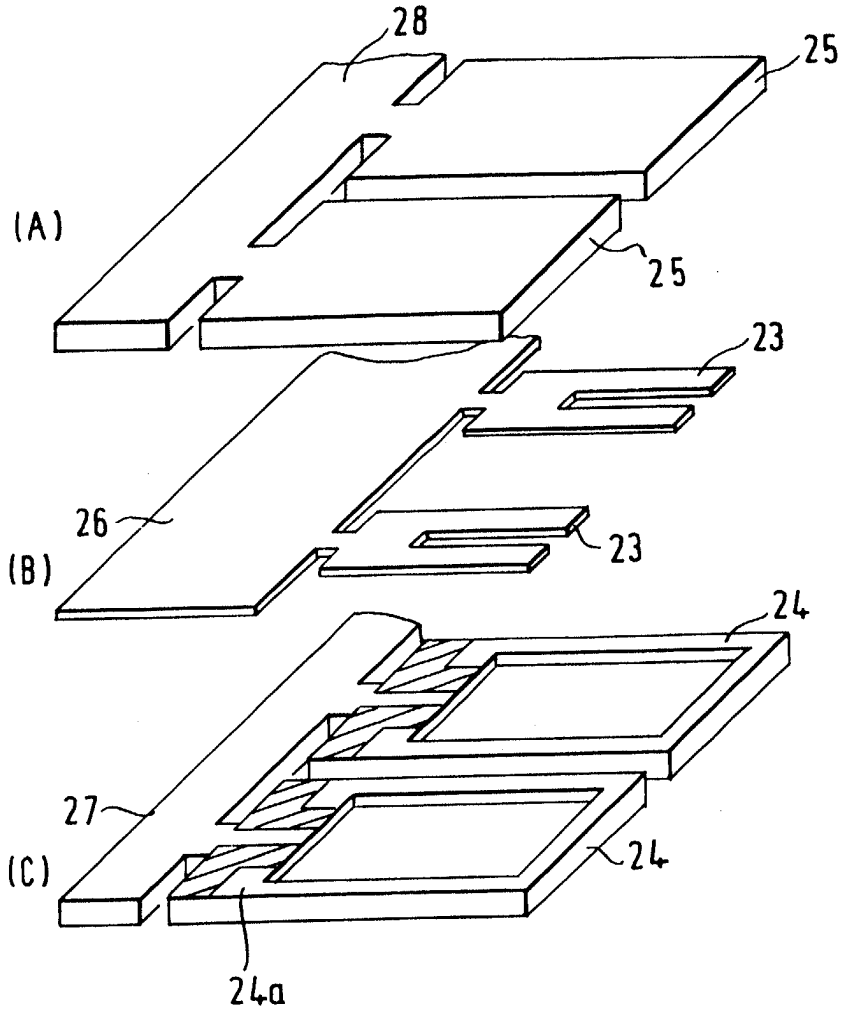
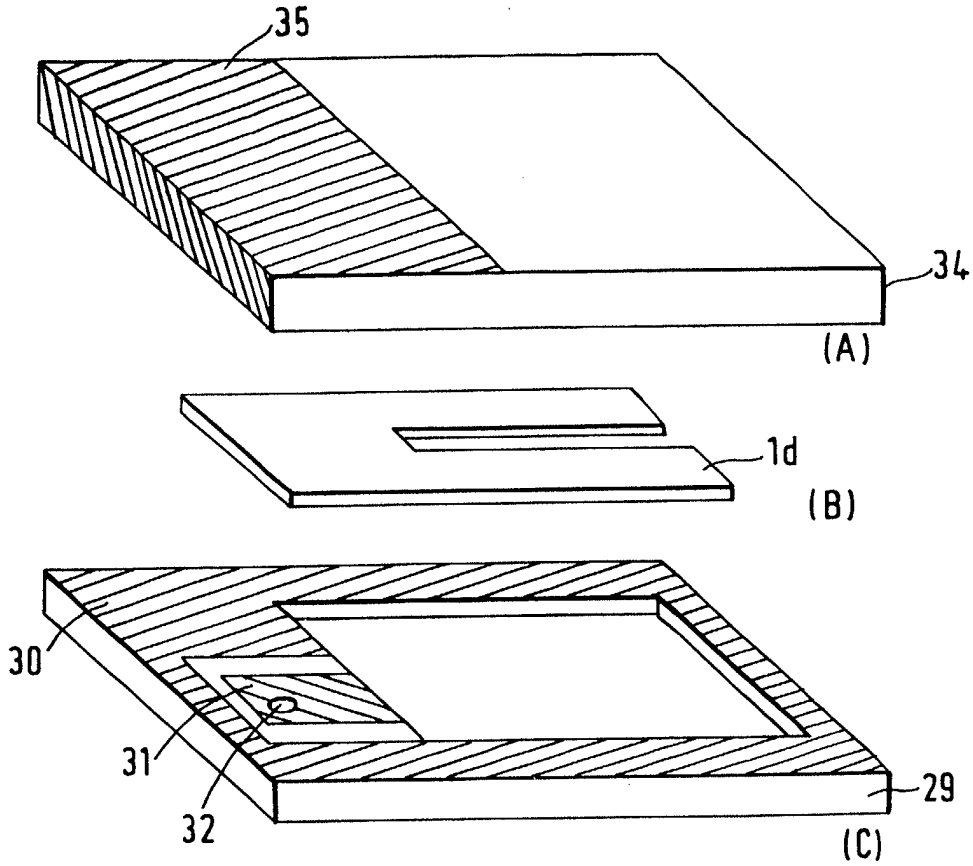


Fig.6.



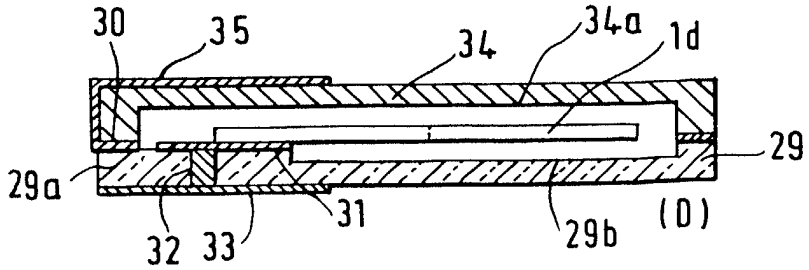
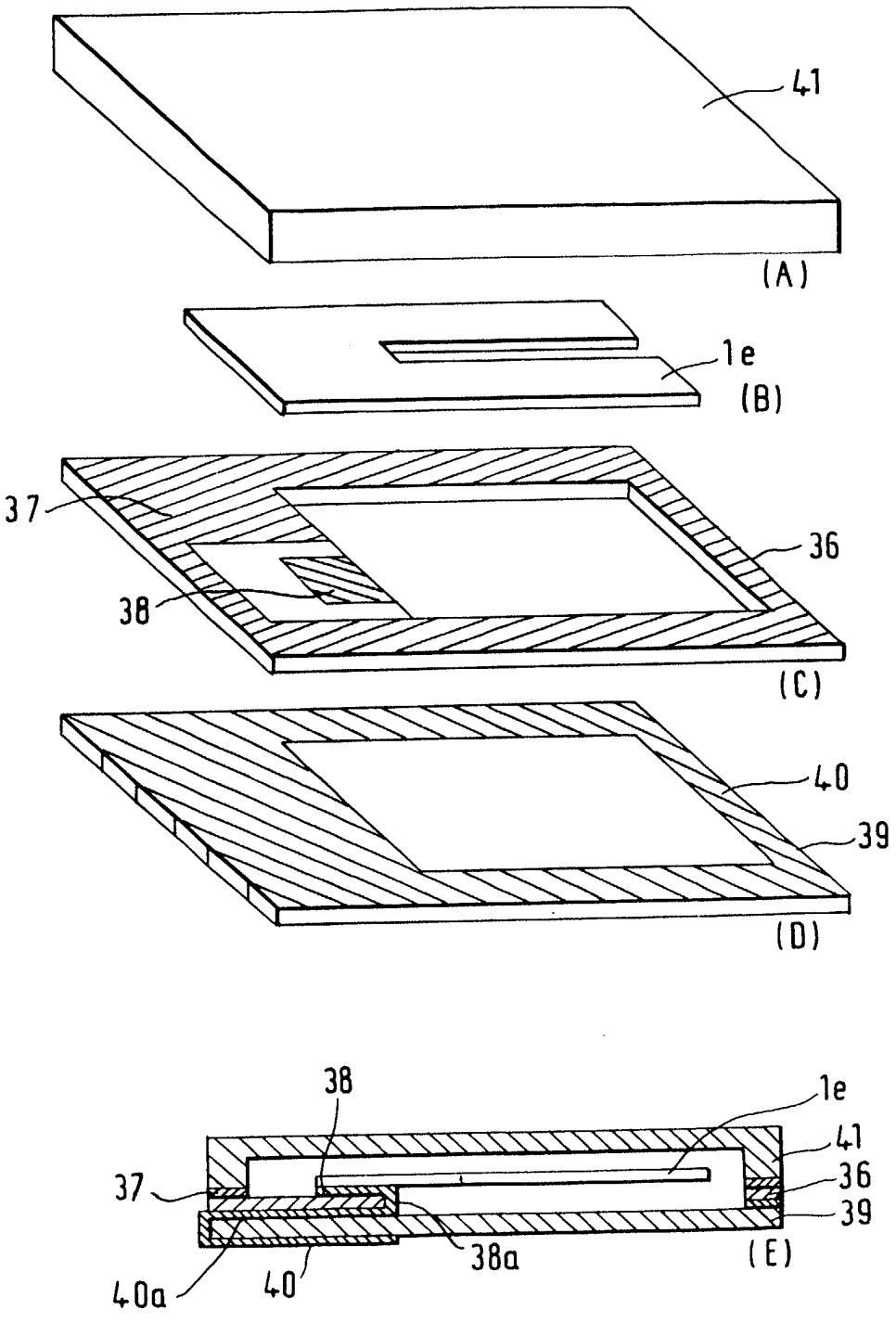


Fig.7.



SPECIFICATION

Oscillator assembly

This invention concerns an oscillator assembly and, although the invention is not so restricted, it is more particularly concerned with a quartz crystal oscillator assembly for use in an electronic watch.

Fashion dictates that a quartz crystal electronic watch should be as thin as possible, and this in turn means that it is desirable to make its oscillator assembly as thin as possible, while ensuring that the assembly is both of low price and high reliability. Conventional quartz crystal oscillators, however, do not enable the watches in which they are used to be especially thin, since they usually have a thickness of 2 to 3 mm. In fact, it is, inter alia, because of the thickness of such assemblies that the quartz crystal electronic watches which use them are thicker than comparable conventional mechanical watches.

According therefore to the present invention there is provided an oscillator assembly comprising an hermatically sealed housing having a plurality of parts at least one of which is made of piezo-electric crystalline material, there being disposed within the housing an oscillator of piezo-electric crystalline material which is mounted on and secured to a support portion of the said one part of the housing. Preferably, the support portion is a planar portion.

Since both the oscillator and the said one part of the housing on which the oscillator is mounted are made of piezo-electric crystalline material, differences in the thermal expansion coefficients of these parts will be reduced, and therefore the degree of distortion which occurs when these parts are secured together is correspondingly reduced, while the provision of a planar support provides a large area of support for the oscillator. This makes it simpler to ensure that the oscillator can be mounted in the correct plane, and therefore reduces the amount of space which has to be provided within the housing. As a result, the invention makes it simpler to provide thin oscillator assemblies of low cost and high reliability. Moreover, since both the oscillator and the said one part are made of piezo-electric crystalline material, they may both be produced by chemical etching processes which further reduce the cost of manufacture and permit the production of thin parts.

Preferably, at least the said one part has a recess into which the oscillator can oscillate.

Each of the said parts of the housing may, if desired, be made of piezo-electric crystalline material.

The said one part and the oscillator are preferably made of the same material, e.g. quartz crystal material.

The oscillator is preferably mounted on two spaced apart electrically conductive films which are provided on the said support portion. Thus at least one of said films may be electrically connected to or is integral with a respective electrically conductive film which is provided on an external surface of a said part of the housing. A said film on the said support portion may be electrically connected to the respective film on the said external surface by means of electrically conductive material disposed within a through hole in the said one part.

The said one part may have a support portion which is separate from but hermetically sealed to a further portion and which defines the said recess therewith, each of the support and further portions being planar members made of the said piezo-electric crystalline material. The said one film may be electrically connected to the said film on the external surface by way of an electrically conductive film disposed between the planar members.

One of the said parts of the housing may be made of electrically conductive metallic material which is in electrical contact with the other film.

The invention also comprises a method of making an oscillator assembly comprising forming a plurality of parts of a housing at least one of which parts is made of piezo-electric crystalline material, mounting an oscillator of piezo-electric material on a support portion of said one part, and hermetically sealing the parts together to form an hermetically sealed housing within which the oscillator is disposed.

Both the oscillator and the said at least one part may be formed by a chemical etching process.

Thus the method may comprise etching a strip of quartz crystal material to form a plurality of oscillators interconnected by strip material; etching a strip of quartz crystal material to form a plurality of first housing parts interconnected by strip material; etching a strip of quartz crystal or other material to form a plurality of second housing parts interconnected by strip material; securing each oscillator to a respective first housing part and thereafter removing the strip material interconnecting the oscillators, securing each second housing part to a respective first housing part to form a plurality of interconnected hermetically sealed assemblies in each of which there is disposed a respective oscillator; and removing the strip material between the assemblies so as to separate the latter from each other.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:–

Figure 1A is a plan view of a lower part of a known quartz crystal oscillator assembly;

Figure 1B is a vertical sectional view of a known oscillator assembly provided with the lower part shown in Figure 1A,

Figures 2A and *2B* are respectively a horizontal sectional view and a vertical sectional view of a known quartz crystal oscillator assembly provided with a cylindrical metallic case,

Figures 3A and *3B* are respectively a horizontal sectional view and a vertical sectional view of another known quartz crystal oscillator employing three ceramic plates and a glass plate,

Figures 4A and *4B* are respectively a horizontal sectional view and a vertical sectional view of a first embodiment of an oscillator assembly according to the present invention,

Figures 5A, 5B and *5C* are respectively perspective views of interconnected upper housing parts, interconnected quartz crystal oscillators, and interconnected lower housing parts of a second embodiment of an oscillator assembly according to the present invention,

Figures 6A, 6B and *6C* are respectively perspective views of an upper housing part, a quartz crystal oscillator, and a lower housing part of a third embodiment of an oscillator assembly according to the present invention,

Figure 6D is a sectional view of a complete oscillator assembly comprising the parts shown in Figures 6A, 6B and 6C,

Figures 7A, 7B, 7C, 7D are respectively perspective views of an upper housing part, an oscillator, an intermediate housing part, and a lower housing part of a fourth embodiment of an oscillator assembly according to the present invention, and

Figure 7E is a sectional view of a complete oscillator assembly formed from the parts shown in Figures 7A to 7D.

Terms such as 'upper' and 'lower', as used in the description below, are to be understood to refer to directions as seen in the accompanying drawings.

In Figure 1 there is shown a known quartz crystal oscillator assembly comprising a quartz crystal oscillator 1, produced by a photo-etching process. The oscillator 1, which is shaped as a two tine tuning fork, is disposed within an hermetically sealed housing comprising an upper housing part 3 and a lower housing part 2 each of which is constituted by a metallic member. The metallic housing parts 2, 3 are hermetically sealed to each other by methods such as cold pressure bonding or welding. The oscillator 1 is mounted on lead wires 4, 5 which are respectively electrically connected to two electrodes (not shown) of the oscillator 1. The lead wires 4,5 extend through and are hermetically sealed in a glass member 7 of a bush 6, the glass member 7 also serving to provide electrical insulation betweev the lead wires 4,5. The bush 6 is itself mounted in and is hermetically sealed (e.g. by brazing) in an aperture in the lower housing part 2.

The oscillator assembly shown in Figure 1 has the following disadvantages:–

1. In order to ensure that the bush 6 is hermetically sealed in the lower housing part 2, it is necessary to provide a bush 6 of considerable axial length and this makes it difficult to make the oscillator assembly thin.

2. The oscillator 1 is connected to the lead wires 4,5 only over very small areas so that it can easily happen that the oscillator 1 is not mounted in the correct plane and extends towards one or other of the housing parts 2, 3. This in turn means that it is necessary to provide a large housing to prevent accidental contact between a housing part and the oscillator 1, and this is another reason why the assembly of Figure 1 cannot be made thin.

3. When the oscillator 1 is fixed to the lead wires 4,5 distortion arises by reason of the difference in the thermal expansion coefficients of the parts, and this renders the assembly very liable to a shift in its frequency if it is adjusted to external shock, e.g. as a result of a fall.

4. The number of parts of the assembly shown in Figure 1 is rather large, and its manufacturing cost is therefore high.

Another known quartz crystal oscillator assembly is shown in Figure 2 and in this case an oscillator 1*a* is disposed within a metallic cylindrical housing 8 having an integral closed end 8*a*. The oscillator 1*a* is mounted on lead wires 9, 10 which are respectively connected to two electrodes (not shown) of the oscillator 1*a* and which extend through a glass member 12. The glass member 12 is hermetically sealed within a bush 11, the bush 11 itself being hermetically sealed within the end of the housing 8 remote from the end 8*a*. The glass member 12 serves to insulate the lead wires 9, 10 from each other and to hermetically seal them within the bush 11. The hermetic sealing of the bush 11 and cylinder 8 may be effected by means of press-fitting, welding and other techniques.

The oscillator assembly shown in Figure 2 has the following disadvantages:–

1. If the external diameter of the metallic housing 8 were to be reduced, this would in turn require the thickness of the oscillator 1*a* to be reduced. It is not however practical to reduce the thickness of the oscillator 1*a* since this would lower its performance.

2. When the oscillator 1*a* is secured to the lead wires 9,10 there is a considerable risk that the oscillator 1*a* will be secured to the lead wires in a position in which the oscillator 1*a* is not disposed perfectly axially of the housing 8. If this occurs, there is a severe risk that the ends of the tines of the oscillator 1*a* will contact the housing 8 and, in order to prevent this, it is necessary to make the latter large.

3. When the oscillator 1*a* is secured to the lead wires 9,10 there is distortion due to the difference between the thermal expansion coefficients of these parts, thus rendering the assembly liable to a change of frequency if subjected to external shock.

In Figure 3 there is shown yet another known oscillator assembly having a quartz crystal oscillator 1*b* which is disposed within a hermetically sealed housing. The said housing comprises a lower housing part 13 constituted by a plate of ceramic material, an upper housinghpart 18 constituted by a glass plate and intermediate housing parts 14, 15 each of which is constituted by a ceramic plate, the intermediate housing member 15 being hermetically sealed to the upper housing part 18 by a layer 15*a* of hermetic adhesive material. Mounted on the intermediate housing member 14 and disposed immediately beneath the intermediate housing member 15 are two spaced apart electrode films 16, 17 each of which is formed of electrically conductive paste, the films 16, 17 being respectively connected electrically to electrodes (not shown) on the oscillator 1*b*.

The oscillator assembly shown in Figure 3 has the following disadvantages:–

1. Since the housing has ceramic parts, it is difficult to secure the parts hermetically together the assembly is made a thin one.

2. When the oscillator 1*b* is mounted on the films 16, 17 contact can occur between the oscillator 1*b* and the intermediate housing part 15, and the latter will not prevent the possibility of contact between the oscillator 1*b* and either the ceramic housing part 13 or the glass housing part 18. Consequently considerable space needs to be provided within the housing, and this prevents the latter from being made thin.

3. Because of the distortion which arises from the different thermal expansion coefficients of the quartz crystal oscillator 1*b* and the ceramic intermediate housing part 14, the frequency of the assembly is liable to shift if the assembly is subjected to an external shock, e.g. by reason of being dropped.

In Figure 4 there is therefore shown a first embodiment of an oscillator assembly according to the present invention, the oscillator assembly comprising a quartz crystal oscillator 1*c* of the tuning fork type, having two tines.

The quartz crystal oscillator 1*c* is provided with two electrodes (not shown) which are respectively electrically connected to electrically conductive thin electrode films 20, 21 which are spaced from each other and which are provided on a planar support portion 19*a* of a quartz (or other piezo-electric) crystal lower housing part 19, the electrodes 20, 21 extending externally of the housing and being adapted to be connected electrically to other parts (not shown). The lower housing part 19 is shaped as a plate and has a recessed portion 19*b*. The assembly also comprises a plate-shaped upper housing part 22 which is mounted on and is hermetically sealed by hermetic adhesive material (not shown) to the lower housing part 19 and to he films 20, 21 to form therewith a hermetically sealed housing for the oscillator 1*c*. The upper housing part 22 is provided with a recessed portion 22*a* so that the oscillator 1*c*, which is mounted on the planar support portion 19*a*, can oscillate either into the recessed portion 19*b* or into the recessed portion 22*a* without contacting the housing parts 19, 22.

The upper housing part 22 may also be made of quartz crystal material or may, alternatively, be made of metal, glass or other material.

Thus in the construction shown in Figure 4, the lower housing part 19 and the oscillator 1*c* are made of the same quartz crystal material and thus the above-mentioned distortion due to different thermal expansion coefficients does not arise.

Figure 5 illustrates a second embodiment of the present invention in which the oscillator assembly comprises a quartz crystal oscillator 23, a plate-shaped quartz crystal lower housing part 24, and a plate-shaped upper housing part 25 which may be formed either of quartz or other piezo-electric crystalline material or may be formed of glass or metal.

The oscillator assembly shown in Figure 5 may be made by photo-etching a strip of quartz crystal material to form a plurality of oscillators 23 which are interconnected by strip material 26. A strip of quartz crystal material is also photo-etched to form a plurality of lower housing parts 24 which are interconnected by strip material 27, the spacing of the lower housing parts 24 from each other corresponding to the spacing of the oscillators 23 from each other.

A strip of quartz crystal material (or if desired metallic or glass material) is photo-etched to form a plurality of upper housing parts 25 interconnected by strip material 28, the spacing between adjacent upper housing parts 25 corresponding to that between lower housing parts 24.

The interconnected oscillators 23 are then placed above the interconnected lower housing parts 24, each oscillator 23 being mounted on a planar support portion 24*a* of a respective lower housing part 24. The oscillators 23 are then secured to the lower housing parts 24 by means of conductive adhesive material (not shown), the various oscillators 23 being simultaneously connected to the corresponding lower housing parts 24. The strip material 26 interconnecting the oscillators 23 is then cut away and the strip of interconnected upper housing parts 25 is placed in position, each upper housing part 26 being adhered and hermetically sealed at the same time to a corresponding lower housing part 24. Thus at this stage a plurality of interconnected hermetically sealed oscillator assemblies are formed in each of which there is disposed a respective oscillator 23. Finally, the strip material 27, 28 interconnecting the various assemblies is cut away so as to enable the assemblies to be separated from each other.

As will be appreciated, the method illustrated in Figure 5 involves the use of a row of oscillators 23 and thus enables the characteristics of all the oscillators of this row to be easily examined simultaneously.

The constructions shown in Figures 4 and 5 having the following advantages.

1. The housing is made of materials such as quartz crystal glass and metallic plate which can be hermetically sealed and enable the oscillator assembly to be as thin as possible.

2. The oscillator is supported on a planar support portion and therefore is stably supported over a wide area. This in turn has the result that the oscillator is less likely to be inclined towards either the upper or the lower housing part and consequently the amount of free space which needs to be provided within the housing can be reduced, thus enabling the oscillator assembly to be made thin.

3. Especially in the case in which the housing is made by etching quartz crystal, glass or metallic sheet material, it is possible to prevent the quartz crystal oscillator from being displaced either horizontally or vertically and it is also possible to make the oscillator small and thin.

4. Since the thermal expansion coefficients of the quartz crystal oscillator is the same as that of the lower housing part, little distortion occurs at the time that they are fixed together. This enables an oscillator assembly of high reliability to be produced.

5. The number of the parts is small and the manufacturing cost is low.

6. If the housing is made by the etching process illustrated in Figure 5, it is easy to automate the manufacturing inspection and assembly and thereby lower manufacturing costs.

In the oscillator assembly shown in Figure 6, a quartz crystal oscillator 1*d* is mounted within a hermetically sealed housing comprising a plate-shaped lower housing part 29 and a plate-shaped upper housing part 34. The lower housing part 29 is made of quartz crystal material and is provided with a planar mounting portion 29*a* for the mounting of the oscillator 1*d*. The oscillator 1*d* can oscillate into a recess 29*b* of the lower housing part 29 and into a recess 34*a* of the upper housing part 34.

The lower housing part 29 is provided with electri-

cally conductive thin films 30, 31 which are respectively electrically connected to electrodes (not shown) on the oscillator 1*d*. Each of these electrically conductive thin films 30, 31 is electrically connected to or is integral with a respective electrically conductive film which is provided on an external surface of the housing. Thus the film 31, which is provided on the support portion 39*a*, is electrically connected to a respective film 33 on the lower external surface of the housing, the support portion 29*a* having a through hole 32 therethrough which is filled with electrically conductive material which serves electrically to interconnect the films 31, 33. The through hole 32 is hermetically sealed by soldering.

The film 30 is electrically connected (by conductive adhesive material, not shown) to a film 35 which is provided on part of one side surface of the housing and on part of the upper external surface thereof, the said conductive adhesive material also being used to effect a hermetic seal between the housing parts 29, 34.

Thus in the construction shown in Figure 6, both the upper and lower external surfaces of the housing are provided with electrodes.

The upper housing part 34 can either be made of quartz crystal material, glass or metallic material. If a metallic upper housing member 34 is employed, then the film 35 is not necessary and the whole of the upper housing part 34 can be used as an electrode.

In Figure 7 there is shown still another embodiment of an oscillator assembly according to the present invention. In this embodiment, an oscillator 1*e* is disposed within a hermetically sealed housing comprising a plate-shaped lower housing part 39, a plate-shaped intermediate housing part 3*b*, and a plate-shaped upper housing part 41. Thus in the Figure 7 construction, the oscillator 1*e* is, in effect, mounted on a planar support portion constituted by the housing part 36, while this support portion is separate from but hermetically sealed to the lower housing part 39 which defines with the intermediate housing part 36 a recess 42 into which the oscillator 1*e* can oscillate.

Both the housing parts 36, 39 are made of quartz crystal material and are provided with electrically conductive thin films. Thus the housing part 36, on which the oscillator 1*e* is mounted, is provided with films 37, 38 which are respectively connected to the electrodes (not shown) on the oscillator 1*e*. The lower housing part 39 is provided with an electrically conductive thin film 40. As clearly shown in Figure 7(E), the film 38 on the intermediate housing part 36 is electrically connected to the film 40 on the lower external surface of the housing by way of a portion 38*a* of the film 38 which bounds the recess 42 and by way of a portion 40*a* of the film 40 which is disposed between the housing parts 36, 39.

The lower housing part 39 is adhesively bonded to the intermediate housing part 36 by means of conductive and adhesive material (not shown).

The upper housing part 41 is made of metallic material and is secured hermetically to the intermediate housing part 36 by conductive and hermetic

1*e* is mounted on a quartz crystal housing part 36, the lower housing part 39 can if desired be made of metallic material. In this case, the provision of the film 40 on the lower external surface of the housing is unnecessary, since the whole of the lower housing part 39 can be used as an electrode. In fact, in the construction of Figure 7, the whole of the housing, except for the housing part 36, may be made of metal.

CLAIMS

1. An oscillator assembly comprising an hermetically sealed housing having a plurality of parts at least one of which is made of piezo-electric crystalline material, there being disposed within the housing an oscillator of piezo-electric crystalline material which is mounted on and secured to a support portion of the said one part of the housing.

2. An oscillator assembly as claimed in claim 1 which the support portion is a planar portion.

3. An oscillator assembly as claimed in claim 1 2 in which at least the said one part has a recess in which the oscillator can oscillate.

4. An oscillator assembly as claimed in any preceding claim in which each of the said parts of the housing is made of piezo-electric crystalline material.

5. An oscillator assembly, as claimed in any preceding claim in which the said one part and the oscillator are made of the same material.

6. Af oscillator assembly as claimed in claim 5 which the material is quartz crystal material.

7. An oscillator assembly as claimed in any preceding claim in which the oscillator is mounted on two spaced apart electrically conductive films which are provided on the said support portion.

8. An oscillator assembly as claimed in claim 7 which at least one of said films is electrically connected to or is integral with a respective electrically conductive film which is provided on an external surface of a said part of the housing.

9. An oscillator assembly as claimed in claim 8 which a said film on the said support portion is electrically connected to the respective film on the said external surface by means of electrically conductiv material disposed within a through hole in the said one part.

10. An oscillator assembly as claimed in claim or in any claim appendant thereto in which the sai one part has a support portion which is separate from but hermetically sealed to a further portion a which defines the said recess therewith, each of th support and further portions being planar membe made of the said piezo-electric crystalline materia

11. An oscillator assembly as claimed in claim and in claim 10 in which the said one film is electri cally connected to the said film on the external su face by way of an electrically conductive film disposed between the planar members.

12. An oscillator assembly as claimed in claim in which one of the said parts of the housing is ma of electrically conductive metallic material which

Printed for Limited, C Published from whic

hereinbefore described with reference to and as shown in any of Figures 4 to 7 of the accompanying drawings.

14. A method of making an oscillator assembly as claimed in claim 1 comprising forming a plurality of parts of a housing at least one of which parts is made of piezo-electric crystalline material, mounting an oscillator of piezo-electric material on a support portion of said one part, and hermetically sealing the parts together to form an hermetically sealed housing within which the oscillator is disposed.

15. A method as claimed in claim 14 in which both the oscillator anf the said at least one part are formed by a chemical etching process.

16. A method as claimed in claim 15 comprising etching a strip of quartz crystal material to form a plurality of oscillators interconnected by strip material; etching a strip of quartz crystal material to form a plurality of first housing parts interconnected by strip material; etching a strip of quartz crystal or other material to form a plurality of second housing parts interconnected by strip material; securing each oscillator to a respective first housing part and thereafter removing the strip material interconnecting the oscillators; securing each second housing part to a respective first housing part to form a plurality of interconnected hermetically sealed assemblies in each of which there is disposed a respective oscillator; and removing the strip material between the assemblies so as to separate the latter from each other.

17. A method of making an oscillator assembly substantially as hereinbefore described with reference to any of Figures 4 to 7 of the accompanying drawings.

18. A quartz crystal oscillator comprising a quartz crystal oscillating leaf manufactured by chemical-etching, being characterised in that said quartz crystal oscillating leaf is securely supported on a bottom case having a supporting portion, and said bottom case is made of crystal plate as one body or is made up of a supporting frame made of crystal plate and a plane plate united with said supporting frame.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon Surrey, 1978.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.